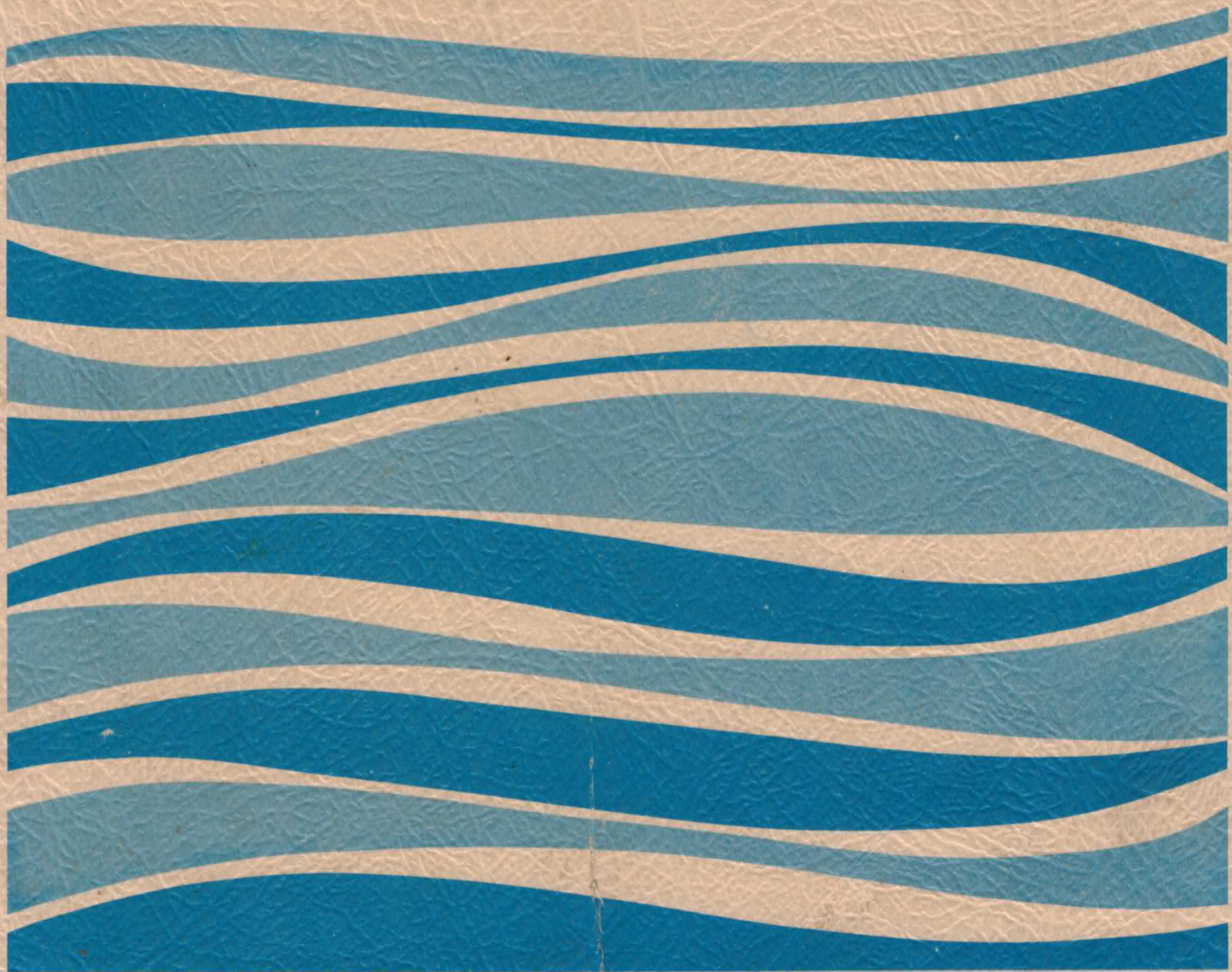
WAGNER®
ENGINEERING LTD.

Marine Hydraulic Steering Systems and Automatic Pilots



WAGNER® ENGINEERING LTD.
Manufacturers of MARINE HYDRAULIC STEERING and AUTOMATIC PILOTS

40 Gostick Place
North Vancouver, B.C.
Canada V7M 3G2

Phone(604) 988-1111
Telex 04-352755
Cable "WAGENG"

THE WAGNER SERIES 50 AUTOPILOT
- PROPORTIONAL CONTROL -
INSTALLATION & OPERATING MANUAL

READ THIS MANUAL CAREFULLY BEFORE ATTEMPTING
INSTALLATION or OPERATION of AUTOPILOT

THE SPECIAL NOTICE ON THE BACK
OF THIS PAGE IS FOR YOUR SAFETY

PLEASE READ IT

SPECIAL NOTICE

An autopilot is not intended to take the place of a man, but rather assist him in steering the vessel.

It is the responsibility of the man (and a requirement by law) to ensure and maintain safe navigation and control of the vessel at all times in accordance with the Rules of the Road.

An autopilot is intended for operation in open waters, clear of all obstructions and other vessels. The heading of the vessel must be observed constantly.

It may be necessary to regain manual steering control quickly and to deactivate the autopilot if the vessel alters or fails to maintain the set course or if the set course may jeopordize the vessel. Determine the best procedure to shut off the autopilot drive unit connected to the steering system.

INSTALLATION AND OPERATING MANUAL

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WAGNER ENGINEERING LTD. WARRANTY

WAGNER warrants that all products of its manufacture meet high standards of quality and performance and are warranted to be free from defective materials and workmanship when used in the manner and service intended for a period of twelve months after delivery.

All products eligible for warranty claims must be sent freight prepaid to WAGNER accompanied by a copy of the delivery documentation. All goods will be returned freight collect by the least expensive means unless advised otherwise. The warranty will not be honoured if, upon examination, it is determined that the equipment has been abused, modified, misapplied, misused, neglected, or contaminated.

The WAGNER warranty provides labour during normal working hours only, and on the premises of WAGNER.

In the event that WAGNER is required to perform warranty work outside their normal working hours or place of business, the following costs or expenses shall be paid for by the customer:

1. All transportation to the job site and return to the normal place of business.
2. All travelling time to the job site and return to the normal place of business - at current service rates.
3. All labour for gaining access to, removing, servicing, replacing and testing WAGNER products, including waiting time - at current service rates.
4. All labour performed by others.
5. Reasonable living expenses if personnel are unable to return to their normal place of business in the same day.
6. All communication charges.
7. All customs duties.

WAGNER will not assume any costs or expenses for special, direct, incidental or consequential damages.

No other warranty or conditions, express or implied, shall be binding upon WAGNER ENGINEERING LTD.

In the case of products supplied, but not manufactured by WAGNER, the warranty will be that of the original manufacturer only.

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WAGNER ENGINEERING LTD.

SERVICE POLICY

For WARRANTY service, refer overleaf to "WAGNER ENGINEERING LTD. WARRANTY".

If service work should be required for WAGNER products beyond the warranty period, the following costs or expenses shall be paid for by the customer:

1. All transportation to the job site and return to the normal place of business.
2. All travelling time to the job site and return to the normal place of business - at current service rates.
3. All labour for gaining access to, removing, servicing, replacing and testing WAGNER products, including waiting time - at current service rates.
4. All labour performed by others.
5. Reasonable living expenses if personnel are unable to return to their normal place of business in the same day.
6. All communication charges.
7. All customs duties.
8. All materials used.

WAGNER will not assume any costs or expenses for special, direct, incidental or consequential damages.

All products shipped to WAGNER for servicing must be sent freight prepaid. All goods will be returned freight collect by the least expensive method unless advised otherwise.

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GENERAL DESCRIPTION of the WAGNER SERIES 50 AUTOPILOT

The WAGNER SERIES 50 AUTOPILOT is a complete automatic steering control system incorporating the latest solid state components. The control unit has wide range controls and uses proportional, integral and differential circuits to give accurate course holding under all conditions. The basic system consists of a control unit, a magnetic compass with a course sensor and a hydraulic drive unit (pumpset). The autopilot system operates from either 12 VDC or 24 VDC and must be specified when ordering.

Options include a permanently mounted remote course setting station, a hand-held remote course setting station and a wind vane sensing unit for sailboat steering. The remote course setting stations include a 'DODGER' switch.

All cables, some available in a choice of lengths, are terminated with coded splash proof plug and socket connectors for easy installation.

SECTION I: AUTOPILOT CONTROLS

SEA STATE

This control incorporates the autopilot ON/OFF switch (operated at the minimum setting -- fully CCW*) and also adjusts the response time of the unit. Decrease SEA STATE in calm seas for maximum course accuracy. Increase SEA STATE in rough seas to prevent unnecessary rudder corrections.

RUDDER

This control incorporates the SET COURSE/PILOT ACTIVE switch (operated at the minimum setting -- fully CCW) and also adjusts the amount of correcting rudder applied. Decrease at high speeds to prevent oversteering. Increase at low speeds (or with following seas, heavy displacement vessels, etc.) to give enough rudder for good course holding. This control also incorporates a remote station selector switch and its use is explained under OPERATION of REMOTE COURSE SETTING STATIONS.

COURSE SETTING

With SEA STATE at 'OFF' (fully CCW), turn RUDDER to 'SET' (fully CCW). Then switch the unit 'ON' by turning SEA STATE in a clockwise direction. Steer the vessel to the desired heading and rotate the course setting dial until the red and green lights above the dial are both out. (NOTE: Both lights will go out on the desired heading as well as on a 180 degree opposite course. Check the magnetic compass card if in doubt). Activate the pilot by rotating RUDDER in a clockwise direction. Adjust SEA STATE and RUDDER to suit the vessel and the sea conditions. To change course, simply turn the course dial to the new heading.

OPERATION of REMOTE COURSE SETTING STATIONS

With the autopilot steering the vessel and SEA STATE and RUDDER in their adjusted positions, pull the RUDDER control outward. This will disable the autopilot. Go to the remote station, select the desired heading and switch to 'ON'. To change course, simply turn the course dial on the remote station to the new heading. To dodge an object in the water, press the spring centred DODGER switch to 'PORT' or 'STBD' as required. The autopilot returns the vessel to the course dial heading when the switch is released.

To return steering to the control unit, switch the remote station 'OFF'. This will disable the remote station. Go to the control unit, select the course heading, push the RUDDER control inward and autopilot control is returned to the control unit. (The remote station must be turned 'OFF' when not in use, otherwise it will adversely affect the operation of the autopilot.)

* CCW -- counter clockwise

BCIL 6549A – W.E.

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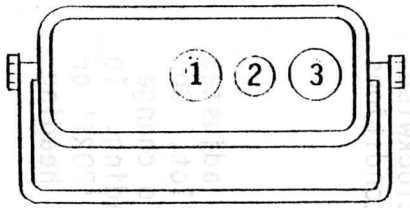
Manufacturers of MARINE HYDRAULIC STEERING GEARS and AUTOMATIC PILOTS

SERIES 50 PROPORTIONAL CONTROL AUTOPILOT CABLING DIAGRAM

DWG No.	REV.
A-4-259A	01

DRAWN: SC

DATE: MAY 80



REAR VIEW OF CONTROL UNIT
SHOWING CABLE LOCATIONS

OPTIONAL MAST HEAD WIND VANE [126-010] SUPPLIED WITH WIND VANE UNIT

OPTIONAL WIND VANE UNIT [510-123]

*(23m)

*(3m)

CONTROL UNIT [510-188]

1 2 3

OPTIONAL JUNCTION BOX [550-091]

POWER SUPPLY (VDC)

*(5m)

CHOICE OF

* 9m: 550-095
12m: 550-119
15m: 550-096

HYDRAULIC DRIVE UNIT
12 VDC: 510-212
24 VDC: 510-213

*(3m).

CHOICE OF

* 5m: 550-092
8m: 550-093
11m: 550-094

*(15m)

*(15m)

OPTIONAL FIXED REMOTE STATION RF-50 [510-232]

OPTIONAL PORTABLE REMOTE STATION RP-50 [510-233]

COMPASS [510-102]

*INDICATES LENGTH OF CABLE SUPPLIED
1 foot = .3 meters

● NOTE: IF ONLY ONE OPTION IS USED, IT MAY BE PLUGGED DIRECTLY INTO (3) ON THE CONTROL UNIT. THE JUNCTION BOX IS NOT REQUIRED.

SECTION II: INSTALLATION PROCEDURE

A. MOUNTING BASIC COMPONENTS

1. COMPASS - The autopilot compass may be used as the main steering compass or it may be remotely located in a position of minimum magnetic interference for best steering accuracy.

   To ensure course setting dial accuracy, the compass lubber line must be carefully aligned with the fore-aft line of the vessel.
   (NOTE: This compass must not be mounted close to any engines, tanks, motors, speakers, transmitting antennas, etc.)

   Minimum safe mounting distances are:

   2 to 3 meters (6 to 9 ft.) from electric winches, engines, radars, electric motors or large iron masses.

   1.5 to 2 meters (4 to 6 ft.) from steering compasses, depth sounders, radiophones, etc.

   1 meter (3 ft.) from any steel structure.

   After installation, the compass should be checked for accuracy and if necessary corrected by a qualified compass adjuster.

2. CONTROL UNIT - This unit should be mounted close to the helm and away from direct sea spray.

   Consideration should be given to ease of cable installation and access for future maintenance when mounting this unit.

3. DRIVE UNIT (PUMPSET) - This unit should be mounted where convenient connection can be made to the steering lines and where the cable supplied (#10 AWG) can be run directly to the batteries. A warm, dry location such as the engine room is usually suitable.

4. REMOTE STATIONS - Optional remote course setting stations are mounted where convenient for installation and service, and where protected from direct rain or sea spray.

B. INTERCONNECTING CABLES (Refer to DWG. No. A-4-259)

All interconnecting cables are supplied with the autopilot system and are of the plug-in type. Standard lengths are indicated on the drawing. Custom lengths of cable are available upon special order, however, the customer is advised to attempt to accommodate the standard cables to avoid delivery delays and extra cost.

SECTION III: TESTS and ADJUSTMENTS

A. DOCKSIDE TESTS (TO BE COMPLETED IN THE ORDER LISTED)

--In case of problems, refer to SECTION V: SERVICE

1. VISUAL CHECKS - All wiring and component mounting must be carefully inspected to avoid possible damage from vibration, chafing, strain, overheating and short circuits from loose wires.

2. POLARITY CHECK - Polarity protection is built in. If the autopilot will not turn on and power is available, the power supply connections may be reversed. RED is POSITIVE. BLACK is NEGATIVE.

3. RUDDER SPEED - Set to approximately 9 seconds hard over to hard over. The speed is adjusted on the pumpset by means of the screw on top of the pump body. Turning this screw in a clockwise direction will decrease the speed. Turning counter clockwise will increase the speed. This screw MUST be locked in position with the locknut after adjusting. To move the rudder hard over to hard over refer to Section 5 below.

4. INITIAL TEST - Centre the rudder using manual steering. Select the 'SET' position on the RUDDER control. Switch the unit 'ON' by turning SEA STATE in a clockwise direction. Rotate the course setting dial slowly until both the RED and GREEN lights go out. This will occur at two places (180 degrees apart). One heading will be within 5 degrees of the required compass course. This is the correct dial setting. Note that the dial must be turned away from the light that is on to extinguish it.

   The compass Index Mark (lubber line) should be forward, if not, the indicated course will not be correct.

   Rotate the course setting dial for a GREEN (starboard) light (about 30 degrees from the course heading) e.g. - If the compass heading is 090, then turn the dial to 120 degrees. Switch to pilot by turning RUDDER in a clockwise direction. The GREEN light will go on and the rudder will move approximately 10 degrees to starboard with RUDDER at minimum; further if RUDDER is increased. The GREEN light will remain on and the rudder will 'creep' further to starboard (automatic trim action).

   IF THE RUDDER MOVES TO PORT -- SHUT THE POWER OFF AND REVERSE THE TWO QUICK CONNECTORS PROVIDED IN THE WIRES FROM THE MOTOR CONTROL BOX TO THE MOTOR, ALSO REVERSE SMALL MOTOR FEEDBACK WIRES

   When the rudder is moving in the correct direction, check that the rudder will move both ways by setting courses about 30 degrees off the compass heading to port and starboard.

5. HARD OVER TO HARD OVER TEST - Dial in a 90 degree course error to starboard and turn RUDDER to maximum. This should move the rudder hard over to starboard. A 90 degree course error to port should move the rudder hard over to port. As mentioned in Section 3, it should take approximately 9 seconds to move from hard over port to hard over starboard.

   This completes the dockside test.

B. SEA TESTS

These tests should be done in an area free of obstacles and where large course changes and steering corrections may be made. Start with a slow vessel speed.

1. COURSE SETTING - Switch the autopilot to 'SET' and adjust the course setting dial to the heading being hand steered (both-lights-out condition). REMEMBER, when you turn the dial away from the light it should go out.

2. OPERATIONAL CHECK - Activate the pilot by rotating RUDDER in a clockwise direction. The autopilot should try to hold the vessel on course. If the vessel goes hard over, recheck that a 180 degree opposite heading was not selected. If necessary, repeat the dockside tests. If the course is set correctly and the rudder still goes hard over repeat DOCKSIDE TEST A/4.

   The autopilot course holding can be improved by adjusting SEA STATE and RUDDER - see SECTION I: AUTOPILOT CONTROLS.

   The SEA STATE control should be adjusted for minimum steering corrections with best course accuracy. This sets the autopilot response time to the sea conditions. In rough weather, SEA STATE is increased so that the autopilot is not constantly working. In calm seas, SEA STATE is decreased.

   The RUDDER control adjusts the amount of correcting rudder applied. If the vessel is moving slowly or operating in following seas, a large rudder movement may be necessary to return to course, therefore, increase RUDDER. If the vessel is travelling at high speed, only a small rudder movement is required and RUDDER should be decreased. Due to wide range adaptive circuits in the autopilot, it may not be necessary to adjust this control for different conditions once an optimum setting has been determined.

   Try the autopilot at varying vessel speeds and different courses to develop a 'feel' for adjusting the controls.

   THE AUTOPILOT SYSTEM CONTAINS A CIRCUIT BREAKER FOR OVERCURRENT PROTECTION. IF THIS BREAKER IS TRIPPED, THE PILOT WILL NOT OPERATE. HOWEVER, IT WILL RESET AUTOMATICALLY IN APPROX. 10 SECONDS. A TURN REQUIRING HARD OVER RUDDER FOR AN EXTENDED PERIOD OF TIME MAY TRIP THE BREAKER. TRIP POINTS ARE: 20A. FOR A 12 VOLT SYSTEM AND 10A. FOR A 24 VOLT SYSTEM.

The pounding motion of a high speed boat in rough water may cause the gimballed compass to swing violently or even tumble 360 degrees, resulting in very erratic autopilot performance. Some form of gimbal restriction should be considered, such as foam rubber, if this is a normal operating condition. A non-gimballed compass could also be considered, in which case the factory should be consulted.

3. INTERNAL SETTINGS - A two position COUNTER RUDDER switch is mounted on the control unit circuit board to accommodate two distinct hull types:

A. Displacement Hulls -- use 'slow' speed switch position
B. Planing Hull -- use 'high' speed switch position.

All units are shipped with this switch in the 'slow' position.

Most owners will be able to classify their boats and therefore, determine the correct switch setting. However, some semi-planing boats are very sensitive to rudder movement and may tend to oversteer (hunt) with the RUDDER control set at mid-position or less. If this is the case, the switch must be turned to the 'high' position.

CAUTION: THIS SWITCH IS LOCKED IN THE 'SLOW' POSITION. TO CHANGE POSITION, THE LOCK MUST BE REMOVED, BOTH SECTIONS OF THE SWITCH ROTATED AND THEN LOCKED TOGETHER AGAIN.

The compass gain is factory preset and should only be reset by a competent technician using the proper test equipment. Normally, adjustment is required only when the compass is not supplied with the autopilot.

To reset the compass gain:

a) Measure the voltage at U5 - pin 7 with respect to pin 19 of the terminal strip (V Reference) in the control unit and rotate the synchro (course setting dial) to the null position (0 volts -- both lights out).

b) Rotate the synchro (or compass) 30 degrees to PORT or STBD and adjust RT1, in the control unit, for a 3 volt reading. Both sides of null should be checked (PORT: -3 volts, STBD: +3 volts).

SECTION IV: TECHNICAL DESCRIPTION

The Series 50 Autopilot, although simple in appearance, employs very sophisticated electronic circuitry. We recommend that internal parts replacement and service be performed by factory authorized technicians if the following circuit theory and details are not fully understood.

Replacement of an entire unit, assembly or circuit board will generally result in faster and more economical field servicing.

A. COMPASS SENSOR

The Wagner compass sensor is a toroidal magnetic flux detector. It is mounted on the underside of the compass bowl. The compass itself is a standard externally gimballed type.

Signals generated in the compass sensor by the magnetic field of the compass card are transmitted to a synchro receiver. This synchro receiver is directly connected to the course setting dial in the control unit and the remote stations. The output signal of the synchro is phase detected to give an error signal proportional to the difference between the compass card heading and the synchro position. With the RUDDER control in the 'SET' position, this signal is used to switch the RED and GREEN course setting lights. When the autopilot is activated, this signal is used to steer the vessel.

B. CIRCUITRY

1. CONTROL UNIT (Refer to DWG. No. B-4-240: Schematic and B-4-264: Test Point Waveforms) - The regulated +8 VDC supply from the motor control box is split by R37 and R38 and buffered by U2, C16, C17, C18 and C31, to provide a signal reference of +4 VDC.

   Integrated circuit, U1, is an oscillator/binary divider providing 420 HZ (Test Point A) and 840 HZ (Test Point C) square waves (± 10%). The 420 HZ feeds integrator, U2-section B, giving a triangle wave (Test Point B) which is buffered and inverted by dual, high current amplifiers in U3. The complementary outputs (Test Point B) provide the primary excitation voltage for the sensor coil, 3 - 4 volts peak to peak.

   The second harmonic signal pulses (Test Point D) generated in the three phase secondary winding of the sensor have varying amplitudes from one to another, corresponding to the sine of the angle of the magnetic field from the compass (and therefore the earth's magnetic meridian). This three phase signal is converted to single phase in the synchro and then to a DC voltage on C8 by gating the signal pulses at 840 HZ (second harmonic) with U4.

   C8 voltage varies ± 0.5 volts (with respect to V Reference) with synchro or compass rotation, being maximum at 90 degrees and null at 0 degrees and 180 degrees.

This signal amplified by U5-section B, is set by gain potentiometer, RT1, to ± 3V (with respect to V Reference) for 30 degree synchro (or compass) rotation off null.

This compass error signal goes to the SEA STATE control and the RED/GREEN (port/starboard) light circuit. U2-section D turns on the appropriate light through Q1 and Q2 when the compass error is greater than ± 300 - 400 mV or approximately 3.5 degrees off null in the 'SET' mode and 3 degrees difference between course selected and rudder angle with the autopilot activated. The lights facilitate course setting before activating the drive unit and also provide a "steer-by-lights' feature when manually steering a desired heading.

When the autopilot is activated, the lights indicate when large rudder corrections are necessary to hold a course. The automatic trim circuit makes corrections for small, persistent course errors over a period of 1 to 3 minutes gradually extinguishing the light as the error diminishes.

The SEA STATE circuit consists of RV1 and C11 and averages course error signals over a time selectable between 10 milliseconds and 6 seconds, reducing rudder movements in heavy seas while maintaining excellent average course holding accuracy.

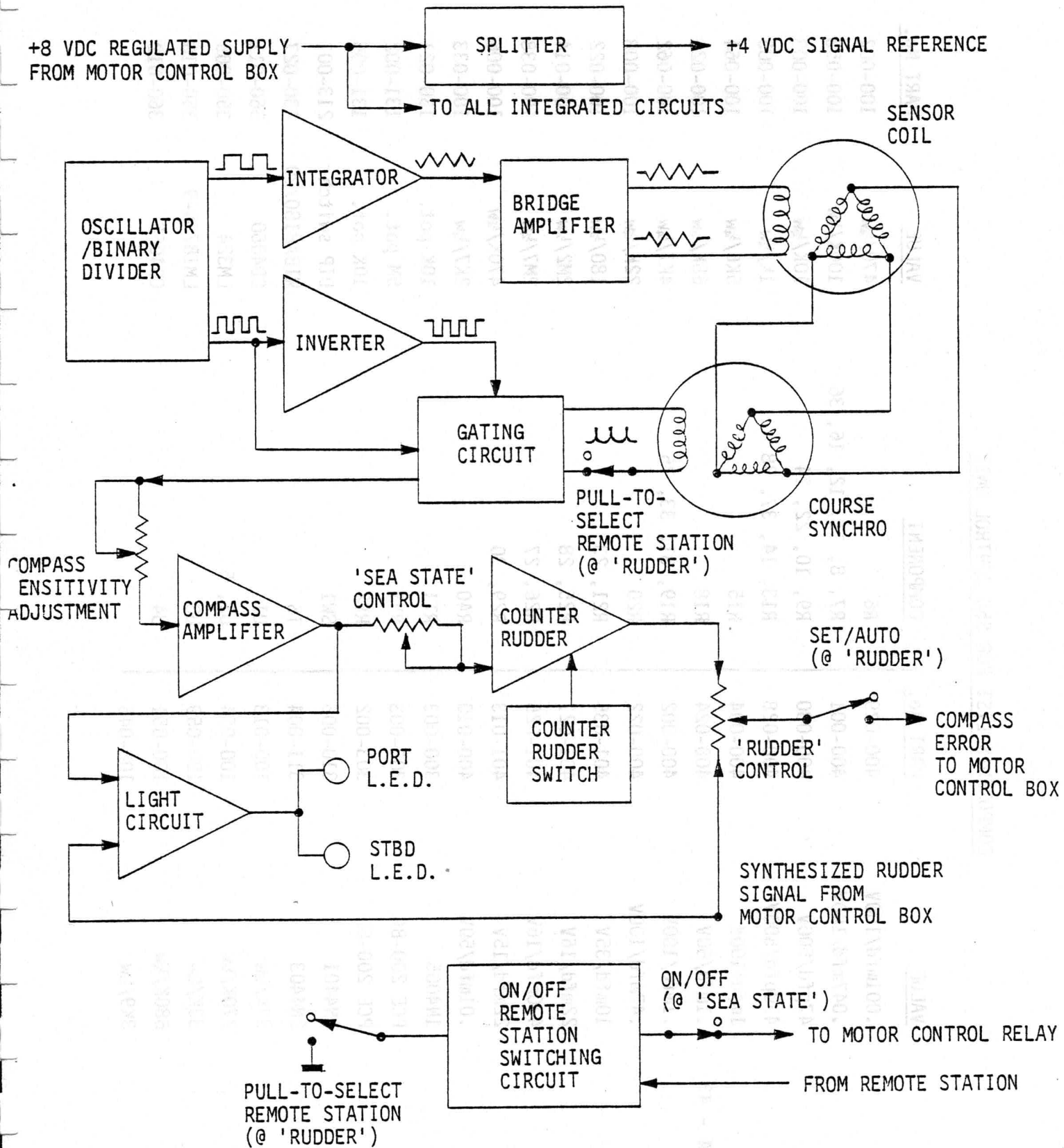
The compass signal then goes to the COUNTER RUDDER circuit, comprised of U5-section A, R25 - R30, C12, C13 and dual switch SW1. This circuit is a differentiator with a DC gain of 1 and switch selectable gain of 5 and 10 for rates of change greater than the RC time constants. Both sections of the switch are locked together on the "high" or "slow" speed settings, according to the vessel's hull type. See SECTION III, B. SEA TESTS, part 3. INTERNAL SETTINGS.

This circuit varies the amount of rudder applied in proportion to the rate of change of heading and provides opposing rudder to eliminate overshoot.

This conditioned signal then goes to the rudder ratio potentiometer, RV2, through limiting resistor, R31, which with R33 from the synthesized rudder (see SECTION IV, B.2. -- MOTOR CONTROL BOX) output, provides a rudder angle versus compass error ratio variable between 3:1 (i.e. 3 degrees compass error calls up a 1 degree rudder correction) and 1:3 (i.e. 1 degree compass error calls up a 3 degree rudder correction).

All leads to and from the control unit circuit board are by-passed by ceramic capacitors for R.F.I. and E.M.I. immunity.

H.F. or V.H.F. transmitters will not affect the course unless their antennas are mounted very close to the autopilot, and/or are grossly mismatched to their antennas.



CONTROL UNIT BLOCK DIAGRAM FOR S50 AUTOPILOT

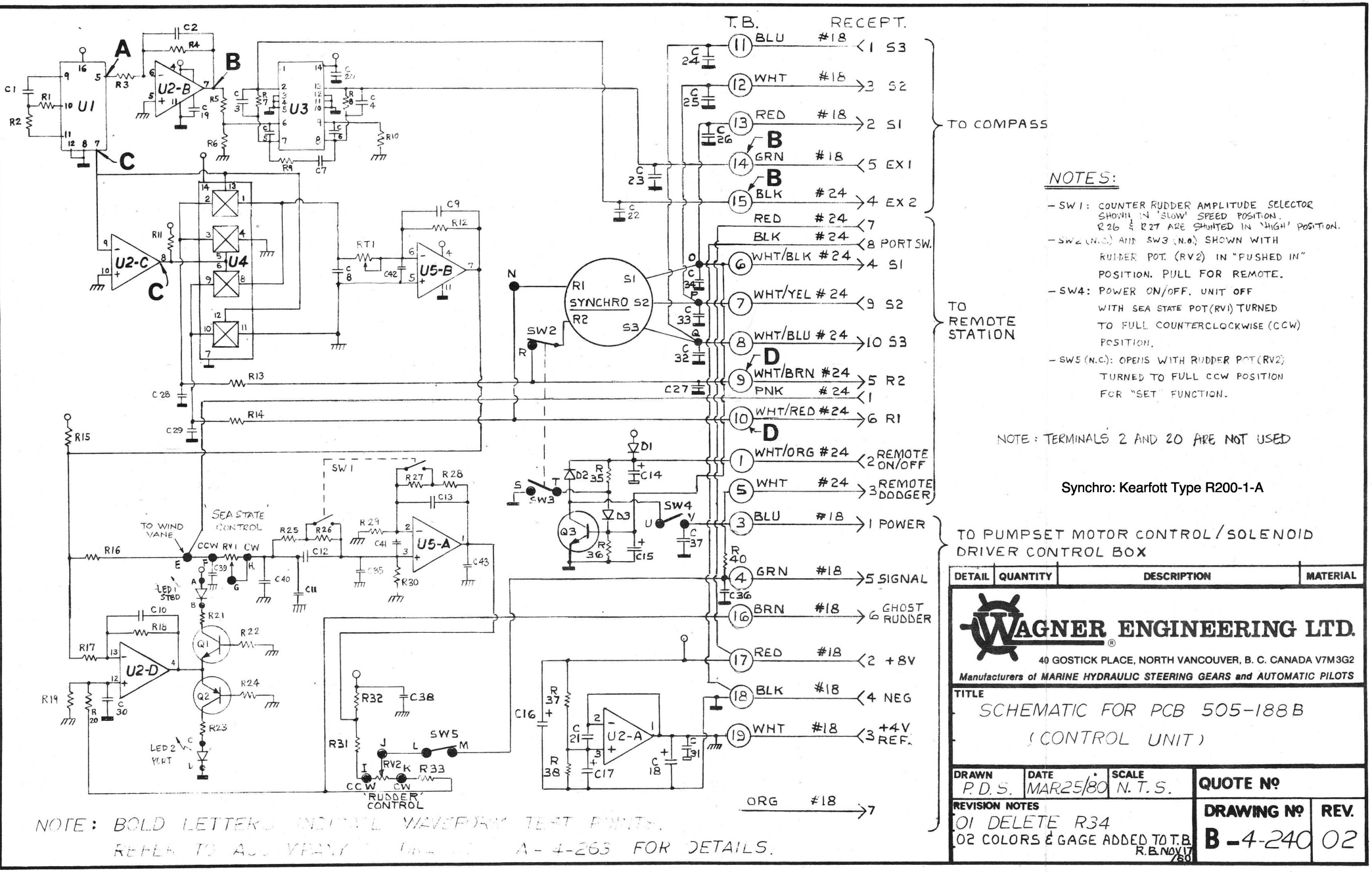
WAGNER ENGINEERING LTD.
40 GOSTICK PLACE, NORTH VANCOUVER, B. C. CANADA V7M3G2
Manufacturers of MARINE HYDRAULIC STEERING GEARS and AUTOMATIC PILOTS

DATE	DWG No.	REV.
JUNE / 80	A-4-265	
DRAWN		

COMPONENTS LIST FOR S50 CONTROL UNIT

COMPONENT	VALUE	PART No.
C1	.001mfd/100V	400-029
C2	.047mfd/100V	400-001
C3, 4	47pfd/500V	400-030
C5, 6, 13	470pfd/500V	400-028
C7, 8, 11	1mfd/100V	400-004
C9, 19 - 21, 24 - 43	.1mfd/50V	400-024
C10	.1mfd/100V	400-002
C12	.47mfd/100V	400-022
C14	10mfd/35V	401-035
C15	22mfd/16V	401-027
C16	470mfd/16V	401-025
C17, 18	22mfd/15V	401-013
C22, 23	.01mfd/50V	400-010
D1, 2, 3	1N4005	300-003
LED 1	PCE 200-BG	303-003
LED 2	PCE 200-BR	303-002
Q1, 3	2N4401	310-006
Q2	2N4403	311-004
R1	27K/¼w	100-013
R2	270K/¼w	100-054
R3, 17	33K/¼w	100-059
R4	680K/¼w	100-051
R5, 32	3K9/¼w	100-045

COMPONENT	VALUE	PART No.
R6	470/¼w	100-002
R7, 8, 11, 12, 16, 36	100K/¼w	100-058
R9, 10, 22, 24	10K/¼w	100-003
R13, 14, 37, 38	1K/¼w	100-005
R15	5K6/¼w	100-064
R18	68K/¼w	100-021
R19, 31, 33, 35	4K7/¼w	100-062
R20	22K/¼w	100-008
R21, 23	180/¼w	100-022
R25, 28	2M2/¼w	100-014
R26, 27	2M7/¼w	100-038
R29, 30	470K/¼w	100-006
R40	2K7/¼w	100-033
RT1	10K pot.	130-021
RV1	5M pot.	131-002
RV2	10K pot.	131-005
SW1	DIP switch	213-001
TS	WIBA8180/20	430-027
U1	CD4060	360-011
U2, 5	LM324	350-005
U3	LM1877N-9	350-010
U4	CD4066	360-012



NOTES:

- SW1: COUNTER RUDDER AMPLITUDE SELECTOR SHOWN IN 'SLOW' SPEED POSITION. R26 & R27 ARE SHUNTED IN 'HIGH' POSITION.
- SW2 (N.C.) AND SW3 (N.O.) SHOWN WITH RUDDER POT. (RV2) IN "PUSHED IN" POSITION. PULL FOR REMOTE.
- SW4: POWER ON/OFF. UNIT OFF WITH SEA STATE POT (RV1) TURNED TO FULL COUNTERCLOCKWISE (CCW) POSITION.
- SW5 (N.C.): OPENS WITH RUDDER POT (RV2) TURNED TO FULL CCW POSITION FOR "SET FUNCTION.

NOTE: TERMINALS 2 AND 20 ARE NOT USED

Synchro: Kearfott Type R200-1-A

NOTE: BOLD LETTERS INDICATE WAVEFORM TEST POINTS. REFER TO ASSY DRWG A-4-263 FOR DETAILS.

DETAIL	QUANTITY	DESCRIPTION	MATERIAL

WAGNER ENGINEERING LTD.

40 GOSTICK PLACE, NORTH VANCOUVER, B. C. CANADA V7M3G2

Manufacturers of MARINE HYDRAULIC STEERING GEARS and AUTOMATIC PILOTS

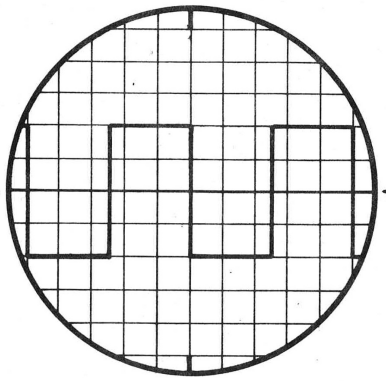
TITLE: SCHEMATIC FOR PCB 505-188B (CONTROL UNIT)

DRAWN	DATE	SCALE	QUOTE Nº
P.D.S.	MAR25/80	N.T.S.	

REVISION NOTES
01 DELETE R34
02 COLORS & GAGE ADDED TO T.B. R.B. NOV 17/80

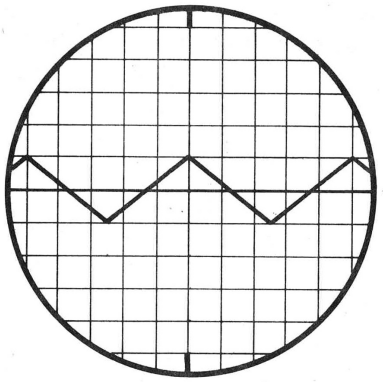
DRAWING Nº	REV.
B-4-240	02

BCIL 6550 B — W.E.



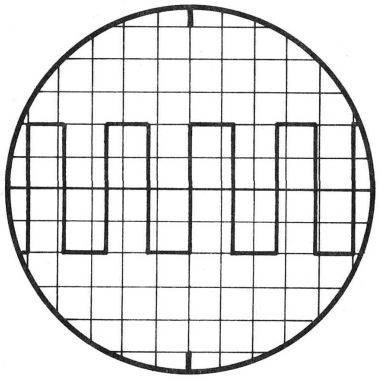
TEST POINT A

V Reference



TEST POINT B

V Reference



TEST POINT C

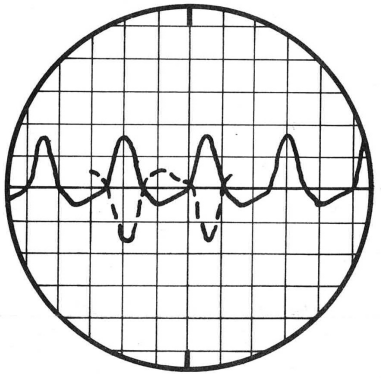
V Reference

FOR ALL WAVEFORMS
Vert: 2 volts/div.
Horiz: 500 microseconds/div.

V Reference: +4 volts

NOTE: Test Point D is measured across terminals 9 and 10

CW -- clockwise
CCW -- counter clockwise

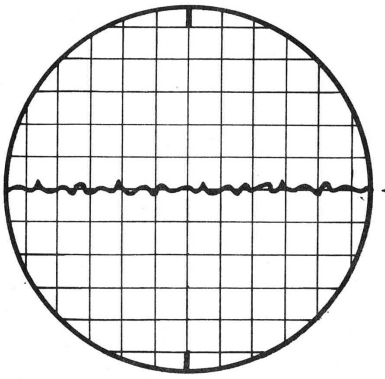


TEST POINT D

CW (+90^{O}) from NULL produces solid line trace

V Reference

CCW (-90^{O}) from NULL produces inverse dotted line trace



TEST POINT D

- at NULL

V Reference

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Manufacturers of MARINE HYDRAULIC STEERING GEARS and AUTOMATIC PILOTS

TITLE

TEST POINT WAVEFORMS
FOR S50 CONTROL UNIT CIRCUIT BOARD

DRAWN

DATE JUNE /80

SCALE —

QUOTE Nº

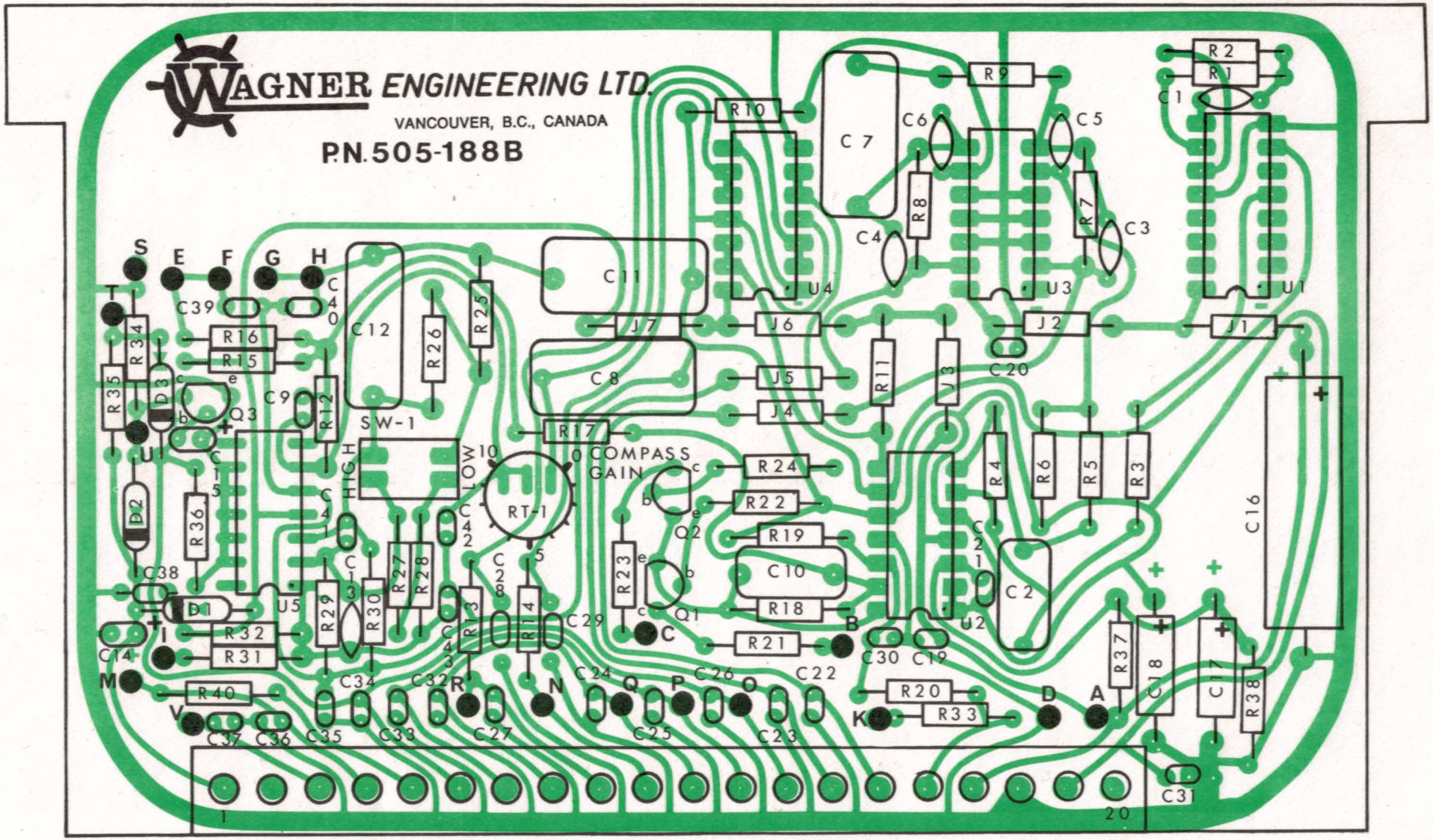
DRAWING Nº B – 4-264

REV.

REVISION NOTES

REF: Dwg. No. B-4-240

DETAIL	QUANTITY	DESCRIPTION	MATERIAL



COMPONENT LAYOUT FOR PCB 505-188B (CONTROL UNIT)

2. MOTOR CONTROL BOX (Refer to DWG. No. B-4-241: Schematic and A-4-263: Test Point Waveforms) - Overcurrent protection to the drive unit electric motor and autopilot circuitry is provided by a thermal circuit breaker. This breaker is automatic and the resetting period is approximately 10 seconds. Trip points are: 20A for 12 volt system and 10A for a 24 volt system.

Transistors, Q1 and Q2; resistors, R1, R2 and R3; capacitor, C1; diodes, D1 and D2; and zener diode, ZD1, comprise a low battery cut-off circuit that prevents turn-on if the battery voltage is reversed or lower than 10V (± 0.5V) in a 12 VDC system or 20V (± 0.5V) in a 24 VDC system. If the battery voltage drops below this cut-off point, the relay will also open preventing damage to the output transistors. If the battery voltage stays below the system voltage (12 or 24 VDC), the relay will not pull in automatically. However, the relay can be closed by switching the pilot off and then on again. This serves as a warning to the operator that the battery is nearly discharged.

Operational amplifier, U1-section D, is a summing amplifier which amplifies the error between the conditioned compass signal and the "ghost rudder" circuit. The output and its complement from inverting amplifier, U1-section C, go to two comparitors with hysteresis, U2-section C and U2-section D.

The comparitors trigger when the amplified error is more negative than 80 mV (with respect to V Reference).

A gated ramp signal (Test Point A) generated by U1-section B and U2-section A goes to the comparitors to provide pulse width proportional control of the motor.

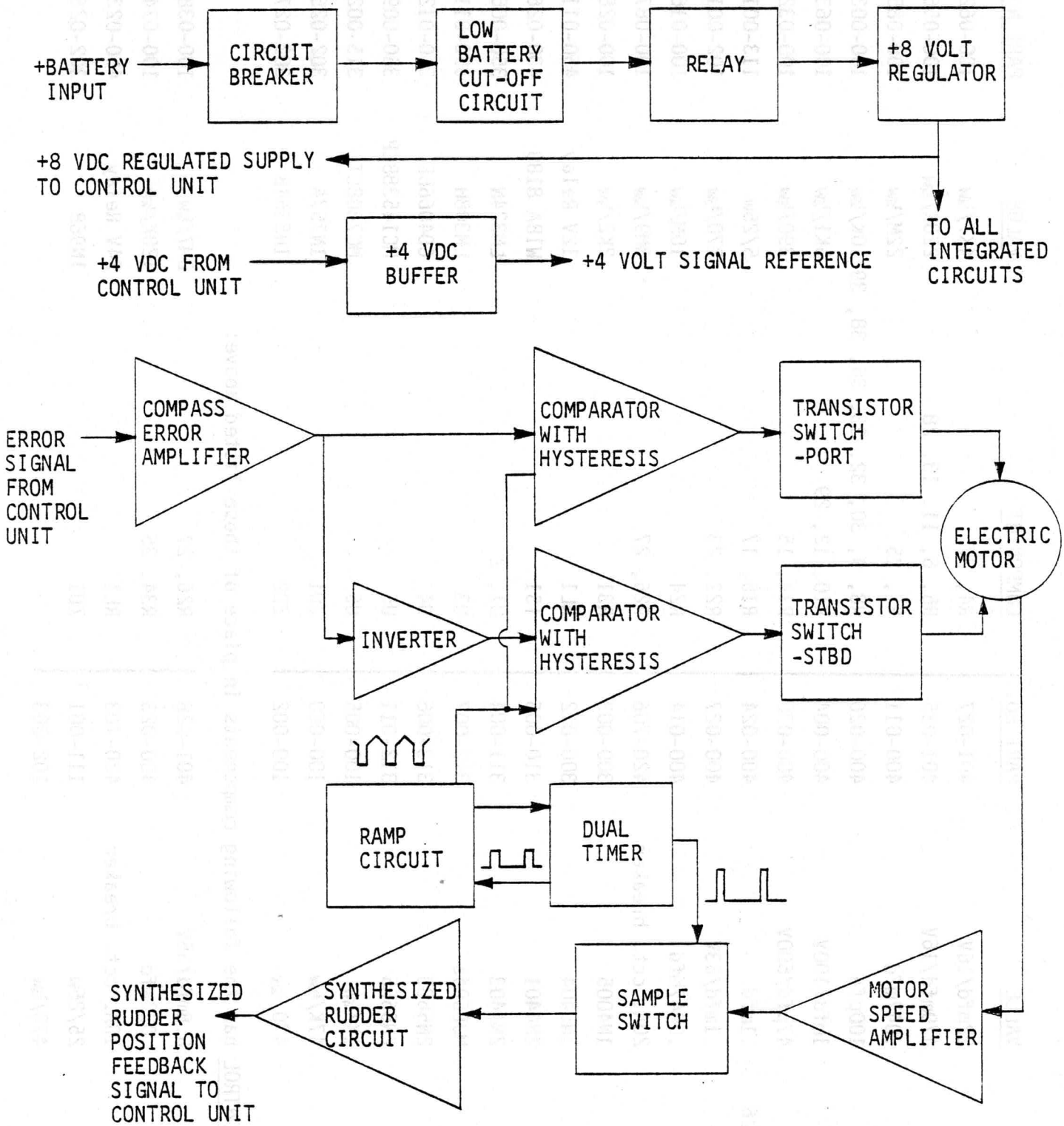
The outputs switch from zero volts off (with respect to battery negative) to 6.5V, turning on Darlingtons, Q3 or Q4, and the respective PNP and NPN complementary pairs, Q5 and Q6; or Q7 and Q8, through base current setting resistors, R16 and R17. Diodes, D3 - D6, protect the output transistors from motor kick-back voltage.

After each ramp waveform, timer U5-section A (Test Point B), clamps both comparitors to negative through CMOS gate, U4, turning the motor off for 0.5 milliseconds allowing the armature field to collapse; then U5-section B (Test Point C) holds the motor off (through U4) while the output of U2-section B, the tachometer output of the motor, is gated through U4 to capacitor, C12.

The voltage on C12, sampled from the motor armature, corresponds to motor speed and is fed back to the error amplifier through R7 and C5 for servo-loop stabilizing and to integrator, U3, to provide the synthesized rudder position feed-back signal.

This synthesized rudder circuit replaces the rudder feedback transmitter found in most conventional autopilot systems. Very accurate (1/20 degree) rudder positional signals relative to the rudder movement and also rudder adjustment in very small averaged increments to correct any course error caused by persistent external effects on the vessel such as wind, current or loading are provided. The two motor power leads are the source of these signals. The low power consumption of the system is the result of this continual averaging and correction.

The synthesized rudder, in place of a rudder transmitter, reduces installation and maintenance costs as well as eliminating a high-probability source of system failure.



MOTOR CONTROL BLOCK DIAGRAM FOR S50 AUTOPILOT

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Manufacturers of MARINE HYDRAULIC STEERING GEARS and AUTOMATIC PILOTS

DATE	DWG No.	REV.
JUNE /80	A-4-266	
DRAWN		

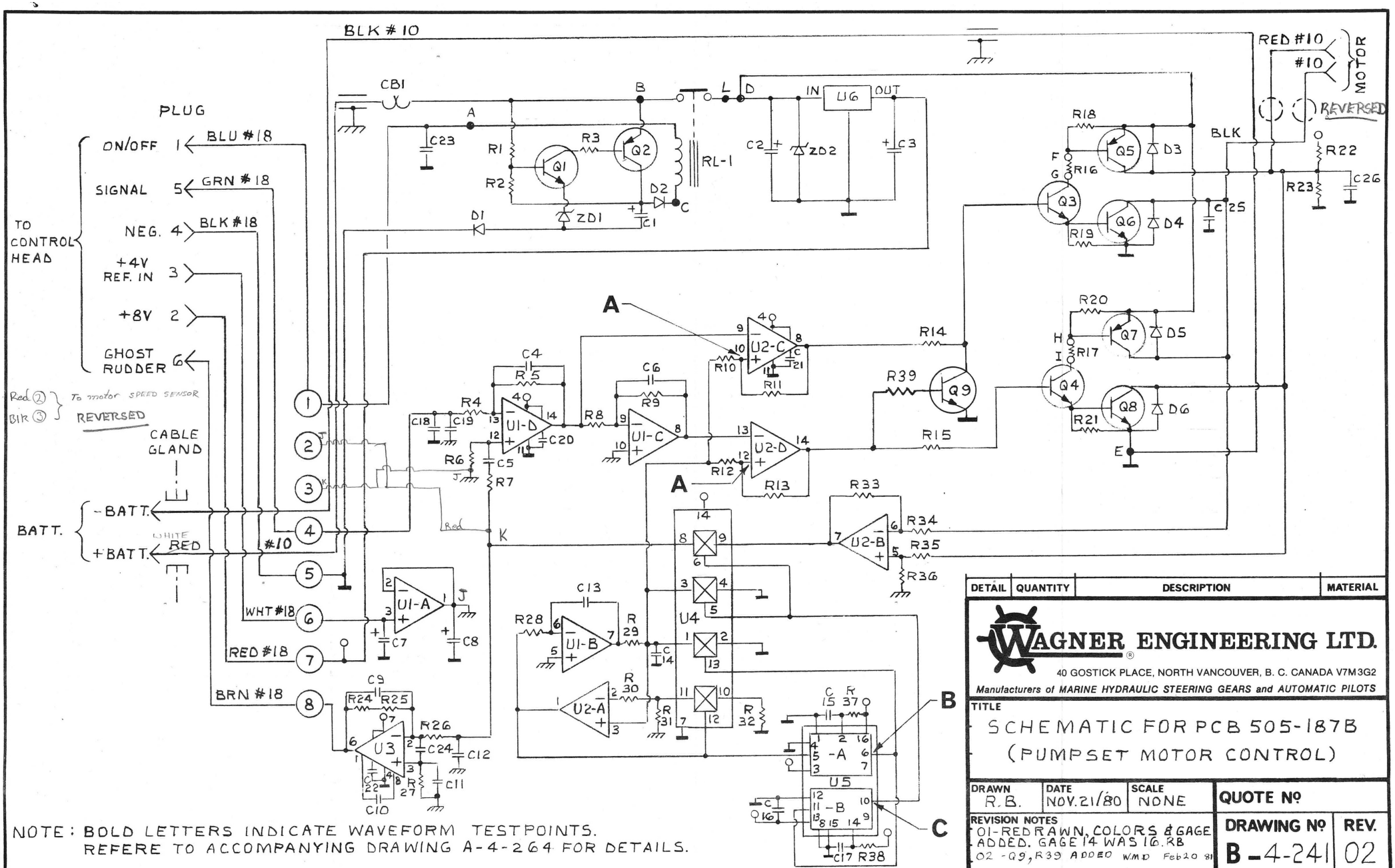
PV125S-XX-PC DRIVE UNIT

COMPONENTS LIST FOR 12 VDC MOTOR CONTROL (*24 VDC at bottom of page)

COMPONENT	VALUE	PART No.
C1, 3, 7, 8	22mfd/16V	401-027
C2	470mfd/16V	401-025
C4, 5	.047mfd	400-011
C6	100pfd	400-026
C9	1mfd/100V	400-004
C10	47pfd/500V	400-030
C11, 12, 16, 18 - 26	.1mfd	400-024
C13, 15, 17	.1mfd/63V	400-027
C14	.0047mfd	400-014
CB1	20A. cct. breaker	420-706
D1, 2	1N4005	300-003
D3, 4, 5, 6	1N5404	300-012
Q1, 9	2N4401	310-006
Q2	2N4403	311-004
Q3, 4	MJE6045	312-007
Q5, 7	2N5683	313-006
Q6, 8	2N5685	312-011
R1, 18 - 21	1K/¼w	100-005
R2, 34, 35	47K/¼w	100-060
R3	470/¼w	100-002
R4, 37	4K7/¼w	100-062
R5, 6, 11, 13, 28	220K/¼w	100-056
R7, 25	22M/¼w	100-085
R8, 9, 30, 32, 33, 36, 38, 39	10K/¼w	100-003
R10, 12, 29	5K1/¼w	100-063
R14, 15	390/¼w	100-032
R16, 17	5/25w	113-001
R22, 23	270/½w	102-001
R24	10M/¼w	100-016
R26, 27	3M9/¼w	100-087
R31	2K2/¼w	100-028
RL1	12V Relay	450-011
TS1	WIBA 8180	430-026
U1, 2	LM324N	350-005
U3	LM308H	350-011
U4	CD4066BE	360-012
U5	MC14538BCP	360-009
U6	MC7808CT	315-002
ZD1	1N757A	302-025
ZD2	1N5364B	302-027

The 24 VDC MOTOR CONTROL has the following components in place of those listed above:

C1	6.8mfd/35V	401-028
C4	.022mfd	400-023
CB1	10A. cct. breaker	420-703
R16, 17	25/25w	111-001
R22, 23	470/½w	102-003
R26, 27	2M7/¼w	100-038
R34, 35	120K/¼w	100-074
RL1	24V Relay	450-023
ZD1	1N968	302-026



DETAIL	QUANTITY	DESCRIPTION	MATERIAL

WAGNER ENGINEERING LTD.

40 GOSTICK PLACE, NORTH VANCOUVER, B. C. CANADA V7M3G2

Manufacturers of MARINE HYDRAULIC STEERING GEARS and AUTOMATIC PILOTS

TITLE

SCHEMATIC FOR PCB 505-187B

(PUMPSET MOTOR CONTROL)

DRAWN	DATE	SCALE	QUOTE Nº
R.B.	NOV. 21/80	NONE	

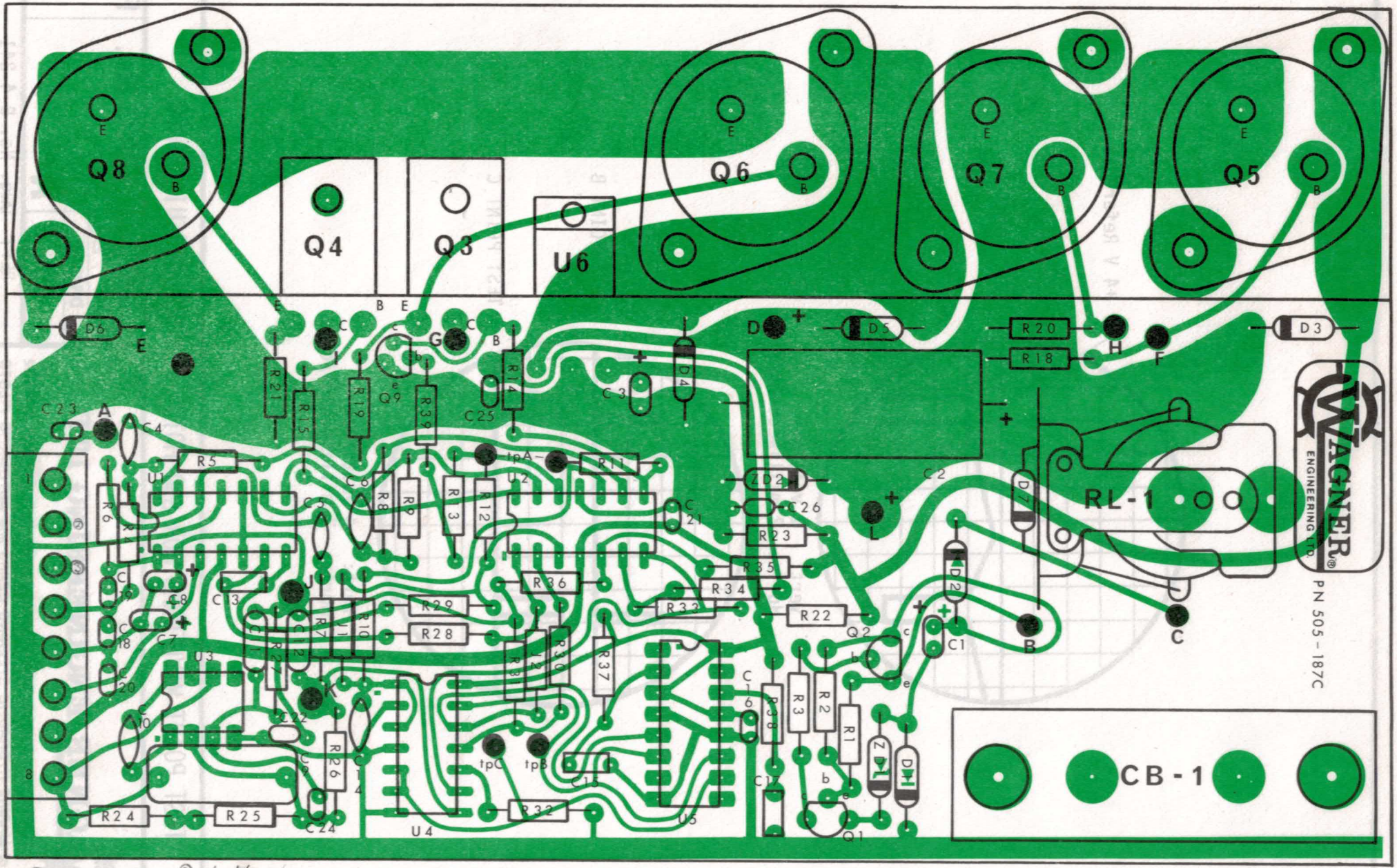
REVISION NOTES

01 - RED RAWN, COLORS & GAGE ADDED. GAGE 14 WAS 16. RB

02 - Q9, R39 ADDED WMD Feb 20 81

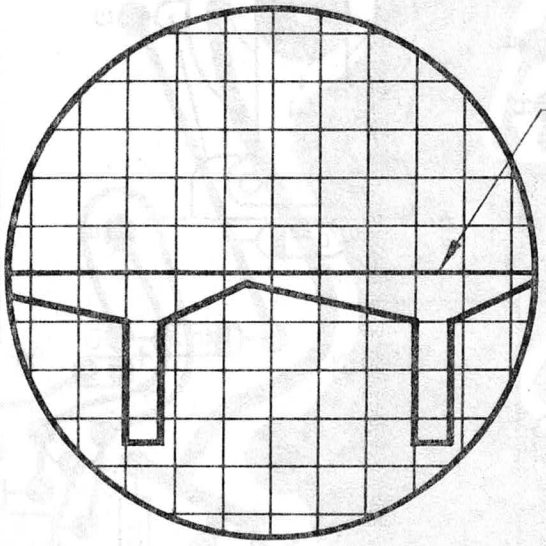
DRAWING Nº	REV.
B-4-241	02

BCIL 6650 B — W.E.



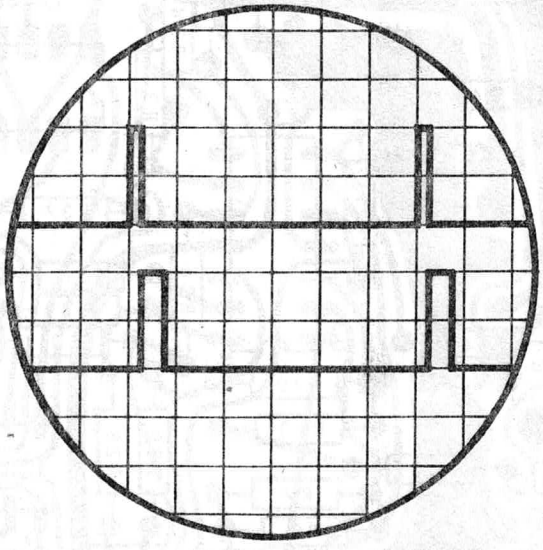
Jumpers: Term ② to K Ref
Term ③ to J

COMPONENT LAYOUT FOR PCB 505-187C (MOTOR CONTROL)



TEST POINT A

Vert: 1 volt/div.
Horiz: 2 milliseconds/div.



TEST POINT B

TEST POINT C

Vert: 4 volts/div.
Horiz: 2 milliseconds/div.

TEST POINT WAVEFORMS FOR S50 MOTOR CONTROL CIRCUIT BOARD

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Manufacturers of MARINE HYDRAULIC STEERING GEARS and AUTOMATIC PILOTS

DATE	DWG No.	REV.
JUNE /80	A-4-263	
DRAWN		

REF: Dwg. No. B-4-241

SECTION V: SERVICE

A. ROUTINE MAINTENANCE

The Series 50 Autopilot is all solid state construction and no routine electrical maintenance is required other than periodic performance checks.

B. TROUBLE SHOOTING

The following test procedure is confined to external checks due to the sophisticated nature of the electronic circuitry. The schematic diagrams accompanying the TECHNICAL DESCRIPTION will allow a competent technician to diagnose any internal component problem. FIELD SERVICE SHOULD ONLY BE ATTEMPTED IF THE OPERATIONAL CHARACTERISTICS OF THE AUTOPILOT ARE FULLY UNDERSTOOD AND ONLY AFTER THE EXTERNAL CHECKS ARE PERFORMED. If all external operations and voltages appear normal yet the autopilot does not function properly, carefully repeat all installation and test procedures in SECTIONS II and III.

NOTE: A good quality voltmeter will be necessary to assure the reliability of required measurements.

1. Turn RUDDER control to 'SET' position (fully CCW)

2. Turn SEA STATE control to 'ON' position (rotate CW).

3. Rotate the course setting dial through 360 degrees -- the RED (port) lamp should be on for 180 degrees of the rotation and the GREEN (starboard) lamp for the remaining 180 degrees.

4. If neither lamp goes on, check the following:

   a) The battery voltage with the electric motor operating. MINIMUM is 11 VDC for a 12 volt system and 22 VDC for a 24 volt system.

   b) The regulated voltage (across C16 in the control unit). THE READING SHOULD BE 7.6 - 8.4 VDC.

   c) The V Reference voltage (across C18 in the control unit). THE READING SHOULD BE ONE-HALF OF REGULATED VOLTAGE MEASURED IN b) above.

   If the regulated voltage is not correct, the problem is a defective integrated circuit, U4, in the motor control box. If either the regulated voltage or the V Reference voltage is not correct, refer to a qualified technician for servicing.

5. If one lamp remains illuminated for more than 180 degrees of the dial or both lamps go out at several places on the dial, check the following:

   a) The compass cable and sensor are properly plugged in.

   b) The cable is not damaged.

   c) The sensor is properly mounted to the underside of the compass. A very close mounting of the sensor to a powerful compass may cause this. Refer to the factory.

   d) The synchro windings and slip rings are not open circuit or intermittent.

6. If the autopilot appears to operate, but follows the wrong course, check the following:

   a) The compass is mounted with the lubber aligned parallel to the fore-aft line of the vessel.

   b) The sensor fore-aft line is aligned with the compass lubber line. The 'F' (fore) mark on the sensor must be forward.

   c) The compass dial or synchro mounting is loose or misaligned.

   d) The rudder turns in a direction to steer the vessel to starboard when the GREEN lamp is on.

   e) The desired course is being set correctly. See SECTION I: AUTOPILOT CONTROLS.

7. If the drive unit (pumpset) does not operate or only rotates in one direction, check the following in the motor control box:

   a) The voltage between terminal 5 and the case of transistors, Q6 and Q8 with the RUDDER control in the 'SET' position. The voltage should be equal to V Reference (3.8 - 4.2 VDC as measured across C16 in the control unit).

      If the case (collector) voltage of Q6 or Q8 is not equal to the V Reference voltage, progressively make the three following checks to isolate the problem:

      1) Check the voltage at U2 - pin 8 and U2 - pin 14. If either pin measurement is more than 1 VDC, the fault is in the preceding circuitry and the problem must be referred to a qualified technician.

      2) Check the voltage across resistors, R16 and R17. If the voltage across either resistor is not zero, the respective transistor, Q3/R16 or Q4/R17, is defective.

3) If steps 1 and 2 above check O.K. and the measured collector voltage is <u>less</u> than the V Reference voltage, then the transistor is shorted, (i.e. Q6 low - Q6 shorted, Q8 low - Q8 shorted). If one transistor is shorted, its complement is likely to be open, (i.e. Q6 shorted - Q7 open, Q8 shorted - Q5 open).

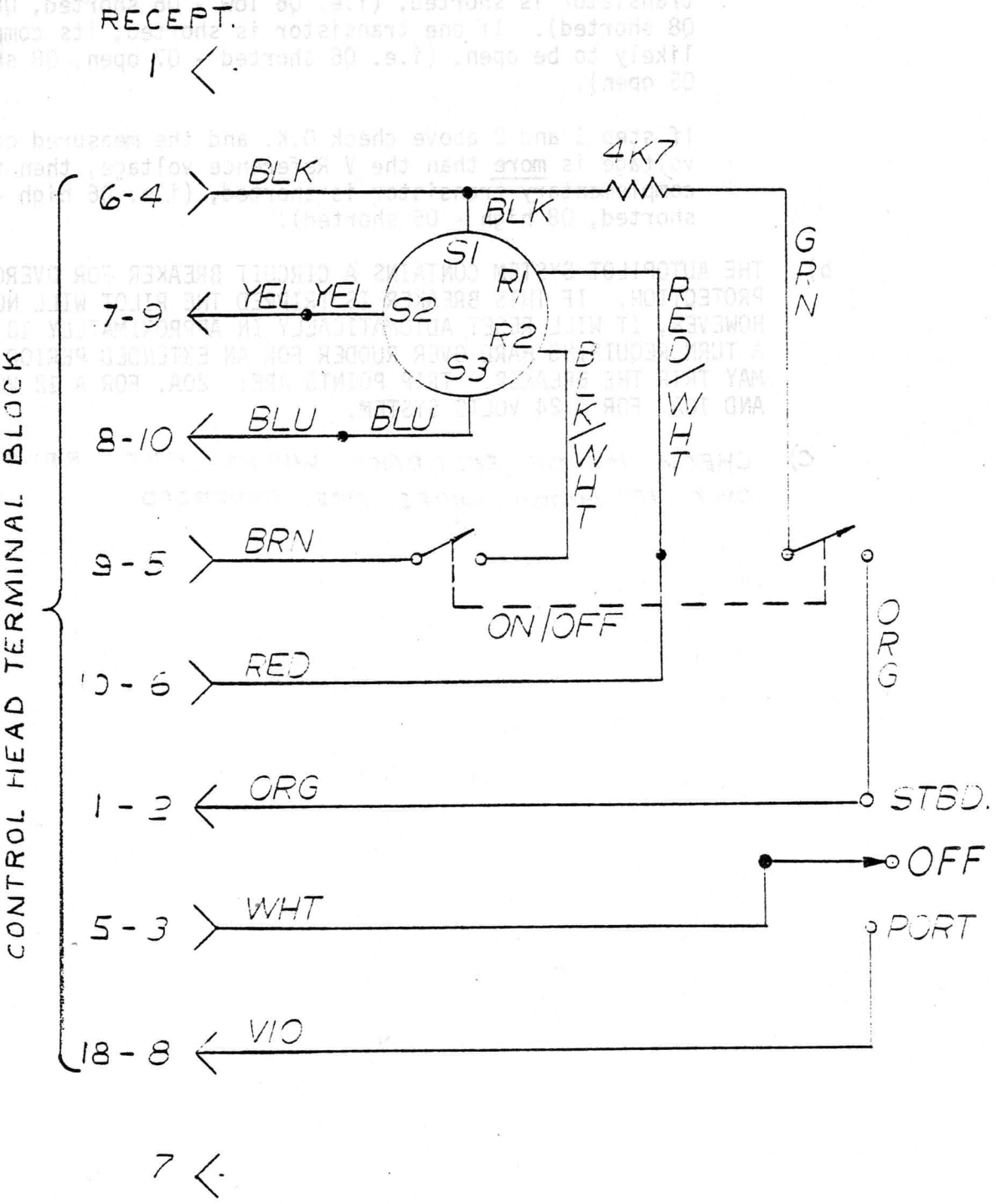
If step 1 and 2 above check O.K. and the measured collector voltage is <u>more</u> than the V Reference voltage, then the complementary transistor is shorted, (i.e. Q6 high - Q7 shorted, Q8 high - Q5 shorted).

b) THE AUTOPILOT SYSTEM CONTAINS A CIRCUIT BREAKER FOR OVERCURRENT PROTECTION. IF THIS BREAKER IS TRIPPED THE PILOT WILL NOT OPERATE. HOWEVER, IT WILL RESET AUTOMATICALLY IN APPROXIMATELY 10 SECOND. A TURN REQUIRING HARD OVER RUDDER FOR AN EXTENDED PERIOD OF TIME MAY TRIP THE BREAKER. TRIP POINTS ARE: 20A. FOR A 12 VOLT SYSTEM AND 10A. FOR A 24 VOLTS SYSTEM.

c) CHECK MOTOR FEEDBACK WIRES ARE REVERSED
ONLY IF MOTOR WIRES ARE REVERSED

NOTES

1. FOR CONTROL UNIT SCHEMATIC SEE DWG. B-4-240-02.



SERIES 50 REMOTE CONTROLS (RP-50 & RF-50) WIRING DIAGRAM

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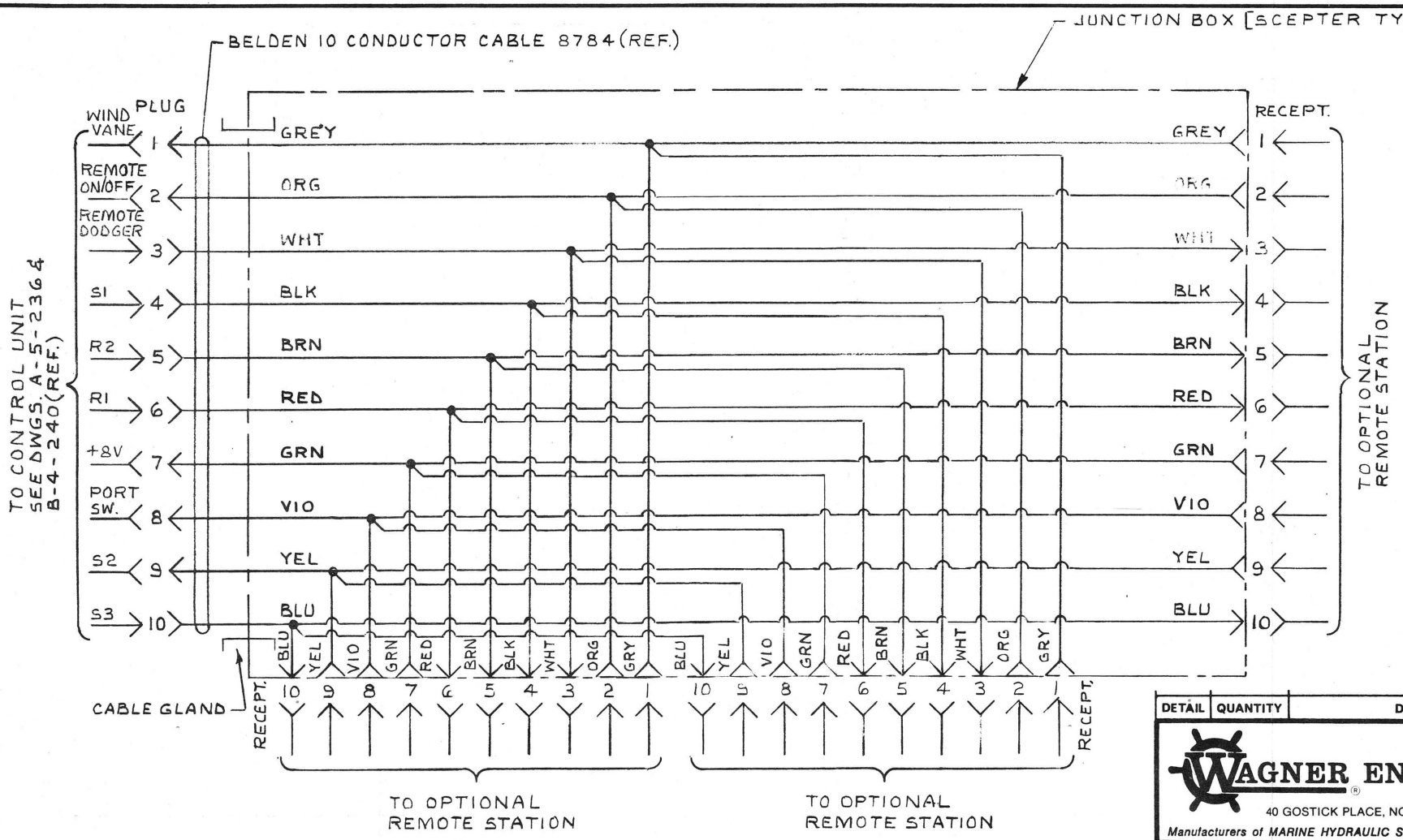
Manufacturers of MARINE HYDRAULIC STEERING GEARS and AUTOMATIC PILOTS

DATE	DWG No.	REV.
JULY 80	A-4-253	02
DRAWN		
SC		



NOTES

1. ALL INTERNAL WIRING TO BE #18 G.A.

DETAIL	QUANTITY	DESCRIPTION	MATERIAL

WAGNER ENGINEERING LTD.

40 GOSTICK PLACE, NORTH VANCOUVER, B. C. CANADA V7M3G2

Manufacturers of MARINE HYDRAULIC STEERING GEARS and AUTOMATIC PILOTS

TITLE

JUNCTION BOX 550-091

WIRING DIAGRAM

DRAWN	DATE	SCALE	QUOTE Nº
R.B.	DEC. 9/80	NONE	

REVISION NOTES

DRAWING Nº B-5-237

REV.

BCIL 6550 B — W.E.

SECTION VI: HYDRAULICS

A. DESCRIPTION OF THE PV125S-XX-PC DRIVE UNIT (Refer to DWG No. A-2991)

The Model PV125S-XX-PC is a proportional rate hydraulic drive unit (pumpset). The package contains a 1/8 HP direct current electric motor coupled to a variable volume bi-directional axial piston pump. A valve block is manifolded to the pump. This valve block contains a lockvalve which isolates the drive unit from the hydraulic steering system, preset relief valves for over pressure protection of the drive unit, 2 suction balls to allow oil entry from the reservoir when filling and periodically during operation and two normally open shutoff valves to isolate the unit from the steering system if required.

The pump is adjusted to achieve a hardover to hardover rudder speed of approximately 9 seconds. The electric motor operates only during course changing or when correction is required and then, only in an amount directly proportional to the error sensed. The autopilot system continually samples the course signal and therefore only small increments of correction or pump operation are required. This results in a very low average power consumption.

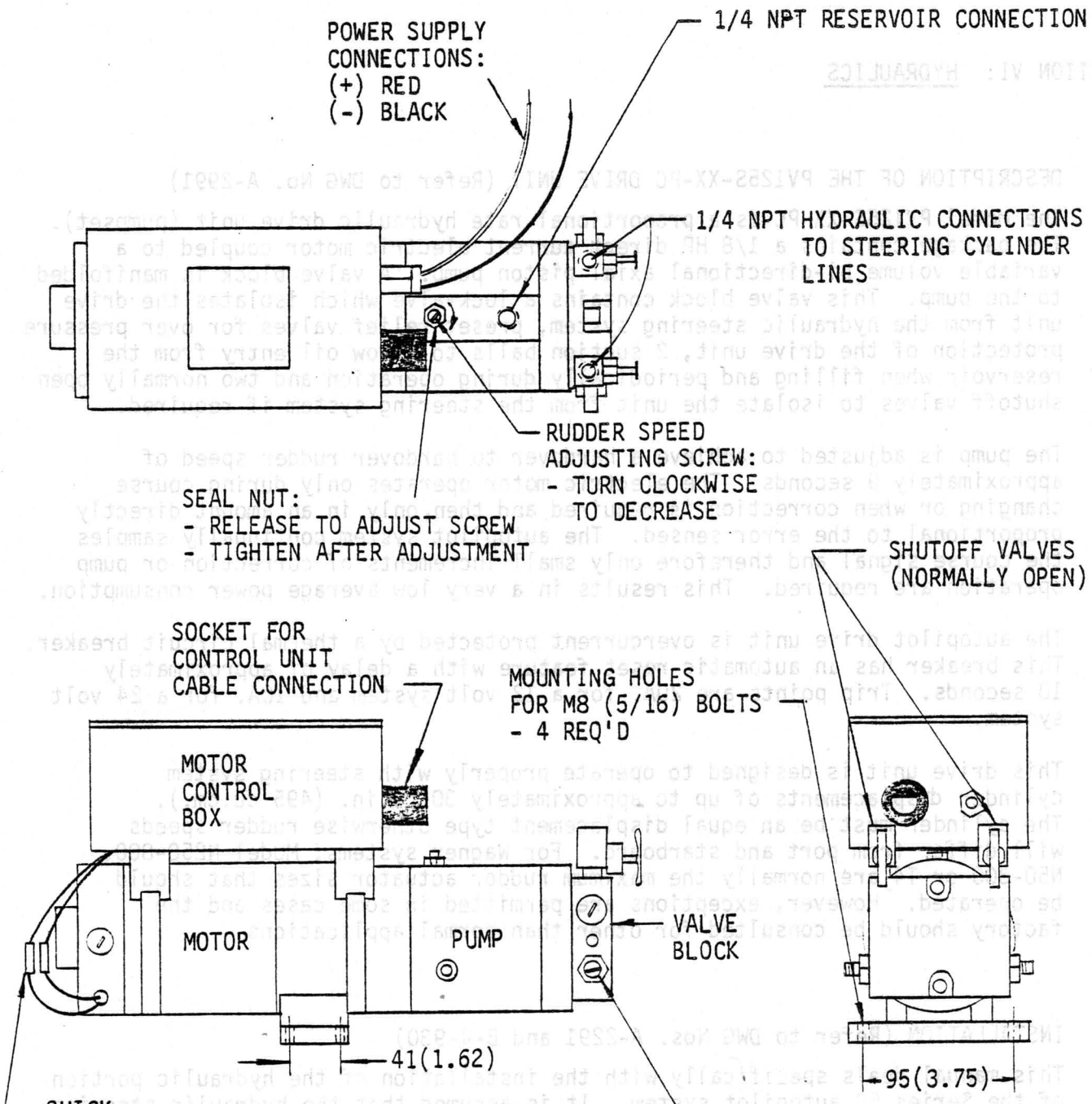
The autopilot drive unit is overcurrent protected by a thermal circuit breaker. This breaker has an automatic reset feature with a delay of approximately 10 seconds. Trip points are 20A. for a 12 volt system and 10A. for a 24 volt system.

This drive unit is designed to operate properly with steering system cylinder displacements of up to approximately 30 cu.in. (495 cu.cm.). The cylinder must be an equal displacement type otherwise rudder speeds will differ from port and starboard. For Wagner systems, Model N250-800, N50-300 or T4 are normally the maximum rudder actuator sizes that should be operated. However, exceptions are permitted in some cases and the factory should be consulted for other than normal applications.

B. INSTALLATION (Refer to DWG Nos. A-2291 and B-4-930)

This manual deals specifically with the installation of the hydraulic portion of the Series 50 autopilot system. It is assumed that the hydraulic steering system has been previously installed. If this autopilot was purchased at the same time as the steering system, the steering should be installed (but not filled with oil) first. The tee fittings for the connection of the drive unit (pumpset) should be put in place during the installation of the steering lines.

Refer to SECTION II: INSTALLATION PROCEDURE, A/3. DRIVE UNIT (PUMPSET) for recommended location of the drive unit. The drive unit may be mounted on a resilient mounting base to isolate vibration and hydraulic noise from the hull of the boat.



OVERALL DIMENSIONS

LENGTH: 370 (14.5)
WIDTH: 125 (4.9)
HEIGHT: 200 (7.9)
WEIGHT: 10 kg (22 lb.)

NPT: AMERICAN NATIONAL PIPE THREAD

ALL DIMENSIONS: mm (in.)

HYDRAULIC DRIVE UNIT (PUMPSET): MODEL PV125X-XX-XC

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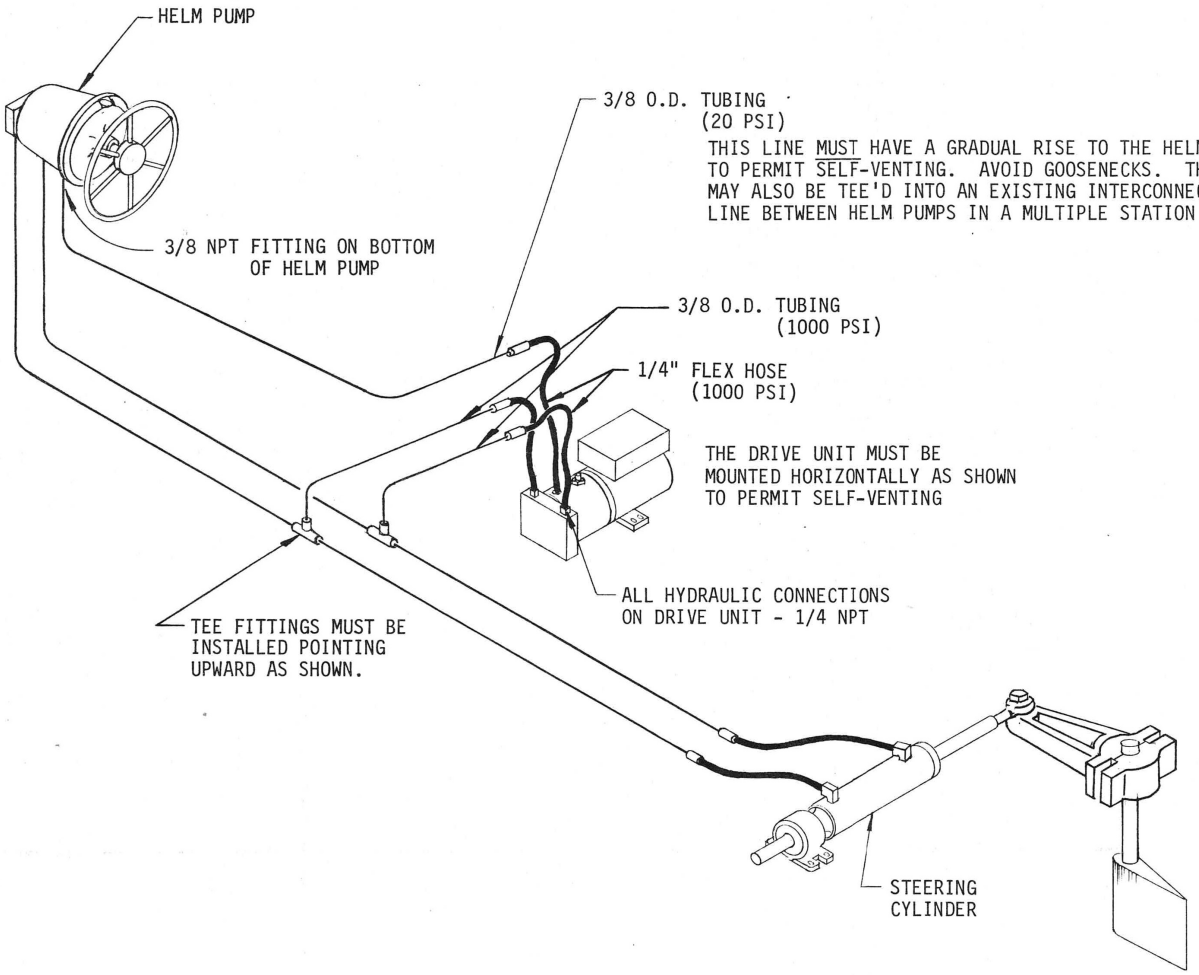
Manufacturers of MARINE HYDRAULIC STEERING GEARS and AUTOMATIC PILOTS

DATE	DWG No.	REV.
MAY 80	A-2291	01
DRAWN		
S C		


HELM PUMP
3/8 O.D. TUBING
(20 PSI)
THIS LINE MUST HAVE A GRADUAL RISE TO THE HELM PUMP
TO PERMIT SELF-VENTING. AVOID GOOSENECKS. THIS LINE
MAY ALSO BE TEE'D INTO AN EXISTING INTERCONNECTING
LINE BETWEEN HELM PUMPS IN A MULTIPLE STATION STEERING SYSTEM.
3/8 NPT FITTING ON BOTTOM
OF HELM PUMP
3/8 O.D. TUBING
(1000 PSI)
1/4" FLEX HOSE
(1000 PSI)
THE DRIVE UNIT MUST BE
MOUNTED HORIZONTALLY AS SHOWN
TO PERMIT SELF-VENTING
ALL HYDRAULIC CONNECTIONS
ON DRIVE UNIT - 1/4 NPT
TEE FITTINGS MUST BE
INSTALLED POINTING
UPWARD AS SHOWN.
STEERING
CYLINDER

NPT: AMERICAN NATIONAL PIPE THREAD

DETAIL	QUANTITY	DESCRIPTION	MATERIAL

WAGNER® ENGINEERING LTD.

40 GOSTICK PLACE, NORTH VANCOUVER, B. C. CANADA V7M3G2

Manufacturers of MARINE HYDRAULIC STEERING GEARS and AUTOMATIC PILOTS

TITLE

MODEL PV125X-XX-XC DRIVE UNIT
WITH MANUAL HYDRAULIC STEERING SYSTEM

DRAWN	DATE	SCALE	QUOTE Nº
TAP	JULY /80	—	

REVISION NOTES

DRAWING Nº	REV.
B – 4-930	01

BCIL 6550 B – W.E.

1. PIPING THE SYSTEM - Keep working conditions as clean as possible. Contamination of any form must be prevented from entering the system. Some common contaminants are Teflon tape, pipe fitting compound, metal filings, any form of dust and pieces of wiping rags. It is essential that all hydraulic tubing is clean inside before starting the installation.

   Teflon tape or pipe fitting compounds, commonly used to seal threaded joints, must be used sparingly and applied only to the male threads. The first two threads of the fitting should not be covered. If it is necessary to remove a fitting for any reason, the female thread must be cleaned before reinstalling the fitting.

   Soft refrigeration-type copper tubing is recommended and should be 3/8 outside diameter and capable of the working pressures as indicated on DWG B-4-930. Flexible tubing must not be used in place of the recommended tubing as it will adversely affect the performance of the system.

   The tubing should be installed with lengths as straight as possible. Bends should be as gradual as possible. Goosenecks (a vertical bend resembling an inverted drain trap, commonly used on the waste drain of a wash basin) must be avoided if possible, otherwise vent plugs must be installed at the high point of the bend to provide a means for removing entrapped air.

   Flare-type fittings are recommended for problem-free connections rather than in-line compression-type fittings.

2. RECOMMENDED OILS - Automatic transmission fluid (red or Type A) is acceptable for use in the hydraulic system, but the following listed oils are preferred due to their superior qualities.

   GULF Harmony AW43 or HVI 47
   ISO ESSO Nuto H 32 or, Univis N 22
   ISO SHELL Tellus 32 or, Tellus T37
   CHEVRON O.C. Turbine Oil No. 11

   ATF no longer recommended except in emergency

   DO NOT USE BRAKE FLUID.

3. FILLING THE SYSTEM - The main steering lines between the helm pump(s) and the steering cylinder must be filled first. The highest (or only) helm pump in the system is also the filler/reservoir for the system and should contain a dipstick. All other helm pumps must be plugged.

   Pour oil slowly into the filler tube and begin turning the wheel at this highest (or only) helm pump steadily in one direction only, checking the oil level periodically to prevent pumping air, until the system begins to feel solid. If the steering system

is a type N with bleed fittings at the cylinder ports, one fitting can be opened slightly (on the side being filled) to purge entrapped air from the lines quickly. If the system does not contain these fittings, the cylinder tubing fitting can be backed out slightly, but wiping rags must be placed under the cylinder to contain the expelled oil.

Now turn the helm pump steadily in the opposite direction until the system again begins to feel solid.

Progress to the next lower pump and repeat this procedure. Remember to periodically check the oil level at the highest helm pump. When all pumps have been turned as described, the steering system should be sufficiently full to be operated by the autopilot system drive unit.

The drive unit should not be operated until the drive unit pump is filled with oil. The tubing fitting on the reservoir connection on top of the pump should be backed out to ensure that the pump is full. Make sure that the two shutoff valves on top of the valve block are open (fully counter clockwise). If the pump seems extremely noisy, it should only be operated in 10 - 15 second intervals until the flow evens out. If the pump is allowed to operate without oil, damage may result.

It will take time for all of the air to be removed from the system, but working it and then allowing it to rest for a few hours is the fastest method of removing the air. It is advisable to keep a wiping rag around the filler during this initial rest period in case oil is foamed out with venting air. The system will not be smoothly responsive until most of the air is expelled.

When the system is full, refer to SECTION III: TESTS and ADJUSTMENTS, A.4. INITIAL TEST and B. SEA TESTS to test the installation of the autopilot system.

C. SERVICE

The oil level should be checked periodically to make sure no leaks have developed. An external inspection of the system components is also suggested to ensure that leakage or other problems are not developing. Normally, no routine maintenance will be required on a properly installed system. All seals are designed for long life in normal service.

The following descriptions of problems and their most likely causes are listed to assist owner field servicing. If a problem cannot be resolved, refer to the factory.

1. If the steering wheel is stiff to turn or the drive unit will not operate the cylinder, check the following:

   a) The rudder stock for binding in its bearings. Remove the cylinder clevis pin and operate the wheel and also the drive unit again. If the cylinder operates, the problem is not in the steering system. If the cylinder does not move and the wheel is still hard to turn, check:

   b) The system is free of entrapped air.

   c) The system is piped using only the two short lengths of flex hose supplied for the cylinder connection.

   d) The hydraulic oil is one of the types recommended, that is, not more viscous (thicker) than automatic transmission fluid.

   e) The tubing used is at least the size recommended.

   f) The shutoff valves on top of the drive unit valve block are not closed. They must be open (fully counter clockwise).

2. If the steering wheel continues to turn easily and the cylinder does not feel like it reaches hardover or the drive unit appears to be pumping, but the cylinder is not responding, check the following:

   a) The cylinder bypass valve (if installed) has been left in the open position. It must be closed.

   b) That all system fittings are tight.

   c) The system is free of entrapped air. If air is in the system, the wheel will spring back when turned and released.

   d) The drive unit valve block is not contaminated. Close both shutoff valves on top of the valve block to check. DO NOT OPERATE DRIVE UNIT WITH VALVES CLOSED. If contaminated, temporarily closing the shutoff valves will restore proper steering and the valve block must be carefully disassembled and cleaned. When removing the slotted inserts, take care not to lose the retained spring and steel ball or to damage the seals.

   e) A lockvalve on another helm pump is not contaminated. This is indicated by the wheel turning at that station. That lockvalve must be disassembled and cleaned. When removing the slotted inserts, take care not to lose the retained spring and steel ball or to damage the seals.

f) The cylinder piston seals are not damaged. All of the above should be checked and determined to be satisfactory first. Remove the cylinder clevis pin and attempt to push the cylinder rod fully back and forth by hand. If the rod moves, the piston seals must be replaced. Oil leaking along the cylinder rod from either end of the cylinder indicates the rods seals are defective and must be replaced.

If there is contamination in the steering system, all components including the helm pumps must be disassembled and cleaned and the tubing flushed. Kerosene, Varsol or Diesel oil is suitable for this flushing operation.

If the quality of the hydraulic oil is questionable, or water appears to be in the system, the system oil should be replaced with new oil from the recommended list.

3. If the drive unit operates the cylinder erratically or the number of wheel turns is different when turning hardover to port and hardover to starboard, check the following:

a) The system is free of entrapped air.

b) The system is piped using only the two short lengths of flex hose supplied for the connection of the cylinder.